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AIRBORNE LASER SEA ICE PROFILES NEAR A DRIFTING CAMP, APRIL 197--ETC(U)
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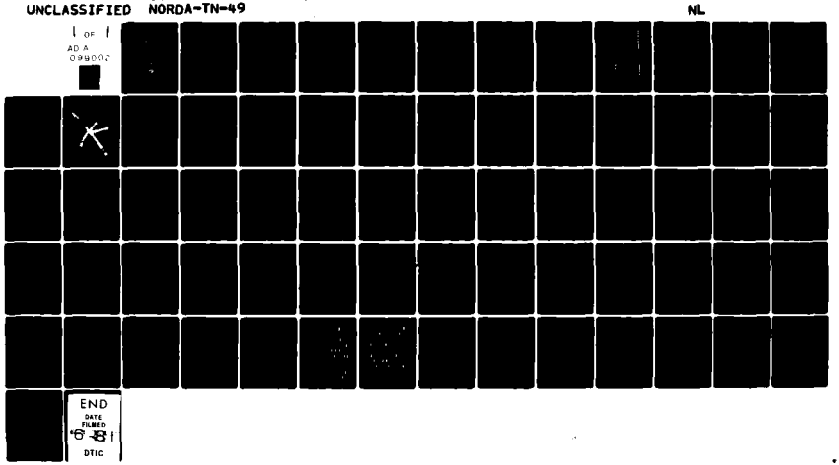

LEVEL II

NORDA Technical Note 49

12

Airborne Laser Sea Ice Profiles Near a Drifting Camp, April 1977

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Oceanography Division
Naval Oceanographic Laboratory

Jun 79

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NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY
NSTL STATION, MISSISSIPPI 39529

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EXECUTIVE SUMMARY

This Technical Note reports the results of reduction and preliminary analysis of airborne-laser sea-ice surface profiles obtained in April 1977 from Fram Strait between northern Greenland and Spitzbergen. Data reduction consists of the removal of discontinuities in the profiles, and numerical computer filtering to remove aircraft motion. Analysis consists of computer calculations of descriptive statistics. The data set chosen is in proximity to an ice camp (Ruby) operated by personnel from the Polar Research Laboratory, Santa Barbara, California. Aerial photography taken simultaneously with the laser profiles serves to place the profile data precisely with respect to Camp Ruby on 12 April 1977.

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TABLES

I. BACKGROUND

The Polar Oceanography Branch of the Naval Ocean Research and Development Activity (NORDA) has on file analog tapes of laser sea-ice surface profiles obtained in the Arctic from P-3A aircraft at approximately six month intervals since 1970. The total amount of data in the library is about 100,000 nautical miles, of which only a small fraction, perhaps 1%, has been reduced and analyzed for specific projects. Sea-ice surface profiles provide statistical information such as spatial frequency of pressure ridges, distributions of ridge heights and spacings, and general sea ice roughness. These parameters are used in either numerical models of sea ice movements and distribution, acoustic models in which sea ice serves as a boundary or a source of ambient noise, or both.

The raw data appear on FM analog tapes. Reduction of the data is made difficult by the presence of aircraft motion (long-wavelength variations in the profile) and various automatic and accidental discontinuities introduced by the recording system. Removal of these extraneous effects has been the subject of numerous papers (Holyer et al., 1977, and Hibler, 1972). Computer programs have been developed which remove aircraft motion numerically, but discontinuities are usually of such an unpredictable nature that they must be treated on an individual basis by a trained analyst, and cannot be removed automatically by computer. It is this individual treatment which makes the data reduction process very slow, and has resulted in the large percentage of data which remain unreduced. The Polar Oceanography Branch is presently developing the capability to reduce this data much more efficiently by means of real-time graphic analysis using a table-top minicomputer. This note, however, describes the scheme presently in use.

II. DATA REDUCTION SCHEME

Data produced on an x-y analog plotter directly from an analog laser profile tape are shown in Figure 1. The slope in the data between points C and B is one example of the long-wavelength aircraft motion superimposed on the terrain profile. The "event" at point A is a ridge about 4.6 m high. The vertical exaggeration of about 30:1 best displays the discontinuities. "Events" at B and C are discontinuities which must be somehow removed so that the "real" profile can be recovered from the data. If these discontinuities are ignored in the data reduction, the program which removes aircraft motion will produce spurious peaks at these locations. These peaks will be counted as ridges. Point B is an automatic shift of the data (back to center-scale) which prevents recordings of analog voltages larger than about 1.5 v (a limitation of the recording system). Point C is a type of discontinuity called a "dropout". Dropouts are almost always a total change of about one-fourth of full scale, but have widely varying shapes. The phenomenon of dropouts is yet to be explained (by anyone, including the manufacturer of the laser profiling system, Spectra Physics). They appear to occur predominately over rough terrain.

Data are usually chosen for reduction on the basis of its proximity to a specific experiment area, such as an acoustic array. Location of the data in time and space is accomplished by comparing the time (simultaneously recorded in flight on a parallel channel of the analog tape) with an aircraft log giving aircraft position. Precise determinations of location can then be made by comparing the laser profile with aerial photography taken simultaneously with the profile.

Data are first plotted on an analog recorder and visually reviewed for quality. Figure 2 shows typical data hand-annotated with the results of a visual review,

with one area marked as unsuitable for further reduction because the number of discontinuities is considered excessive. "Hand" removal of so many discontinuities might lead to unreliable descriptive statistics. The "unsuitable" section (Fig. 2) where several closely spaced data shifts are shown may indicate that the aircraft was executing a maneuver such as an altitude change or turn. This condition would result in the laser beam pointing obliquely at the terrain, thus giving erroneous ridge heights.

When it has been decided which profiled area is to be reduced, the profile is digitized using an A/D converter, onto a 7-track computer-compatible tape. Data are recorded in millivolts (-1500 to +1500 mv) and are sampled at about 200 Hz. Since the aircraft ground speed is usually 180 to 250 knots, this amounts to an actual data point spacing of 0.46-0.64 m. Average data point spacing used is 0.5 m. One digital record is usually 15,000 points, or about 7500 m in length.

Figure 2 also shows time and data-point-number scales added by hand to the analog trace. This procedure approximately locates discontinuities in the digital record. The approximate locations can then be used to obtain a print listing of the small portions of the record near the discontinuity, or the entire record can be computer-listed (in millivolts) and the locations used as a guide in finding the discontinuities and removing them.

Table 1 shows a computer listing of data in the vicinity of a data shift. A notation is made to add +1600 mv to each data point after point number 5127. If another discontinuity is reached later in the record, further corrections are then necessary.

Table 2 shows a computer listing of data in the vicinity of a "dropout." A series of corrections, amounting to subtracting a sloping straight line, is shown in Figure 3 (see Holyer et al., 1977). The plot (Fig. 3) of the data shows the extent of the discontinuity.

The cumulative corrections are applied to the data in the computer, and checked by listing and inspecting the corrected record. When all corrections are satisfactory, the data are ready for numerical filtering and computation of statistics. These two final steps are performed in one computer run by an algorithm suggested by Hibler (1972).

The procedure outlined above has been used on a recently acquired data set to demonstrate the output of the computer programs and the presentation of results.

III. DATA NEAR SEA ICE CAMP RUBY, 1977

In April 1977, personnel from NORDA's Polar Oceanography Branch operated sensors aboard the Naval Oceanographic Office's (NAVOCEANO) P-3A BIRDSEYE aircraft as part of a field experiment in the Fram Strait (between Greenland and Spitzbergen). Data were gathered around two drifting sea ice stations, Ruby and Pearl, which were operated by personnel of the Polar Research Laboratory, Santa Barbara, California. The locations of the camps are shown in Figure 4.

Acoustic experiments were performed in the sea in the vicinity of Camp Ruby, and airborne laser profiles and 9 x 9 in aerial photographs were made of the sea ice terrain on 12 April. The profiles and photography provided the relative locations and statistical terrain features of the sea ice near Camp Ruby for 12 April, and for as many days before and after 12 April, as the ice remained in

nearly the same configuration near the camp. (On 12 April at 1517Z, the camp was located at 8217N 0652W, according to the LTN-51 inertial navigation system aboard the aircraft). Figure 5 is an uncontrolled photomosaic of the area of Camp Ruby, using the 9 X 9 inch cartographic quality aerial photographs.

Figure 6 is an analog trace of the uncorrected profile data. In this particular data set, all data were considered reliable. File and record numbers referring to the digital data tape are annotated on the trace, and serve to name the record. Many discontinuities (a total of 49) are to be found. Each must be removed individually by the procedure described in the previous sections.

After the data are resampled and numerically filtered with the existing FORTRAN program, each final record contains exactly 4980 data points, with aircraft motion and discontinuities removed.

IV. SUMMARY OF RESULTS

Appendix 1 contains all final reduced data (with terrain height in meters) obtained from the uncorrected data plotted in Figure 6.

Appendix 2 is a reproduction of the computer listings summarizing the data in each record in Appendix 1. The ridges counted are listed individually by height ("Z(M)"), position in the record (data point "I"), and distance from the beginning of the record in kilometers ("KM"), which provides scaling to the actual terrain. Provision is made for 120 ridges in the listing, but in this particular analysis, excess ridges are hand annotated on the page. Excess ridges are located by inspection of the appropriate data in Appendix 1. Another table in the listing, headed "STATISTICS OF COUNTED RIDGES," gives the height ranges (bins) into which ridges are placed according to height, the number in each range, and the number per kilometer in each range for this record. A third table headed "PROFILE STATISTICS," is based on the entire record, not individual ridges, and contains the mean, root-mean-square (RMS), etc., of the data. Other information provided in the listing includes the aircraft groundspeed, data point spacing, number of data points in the record, actual length of the record in kilometers, number of ridges counted, and the location of the highest ridge in the record.

Ridges are counted by the Rayleigh criterion (borrowed from optics), where a local maximum terrain height (over 0.5 m in this case) is counted as a ridge if adjacent minima in both directions are less than one half the maximum. No minimum ridge spacing or maximum terrain slope is considered (see Diachok, 1975).

The print listing is designed to provide a general analysis of the terrain included in the record. It is expected that individual applications of the data may use only a small portion of this information.

Figure 7 shows the location of each record with respect to the terrain. This step is performed using either a plot (not shown) of the final reduced data, or an analog trace such as Figure 6, and comparing ridges seen in the photography with those in the profile. The user can employ Figure 7 to map required ice parameters as a function of position. Since, in effect, each data point (terrain height) is now located, it is possible to re-analyze the data in any desired way and tie the results to an experiment conducted in the area. For one example, one may use a sliding window to compute a continuous RMS, or ridge spacing as a function of position.

V. REFERENCES

Diachok, O. I. (1975). A Simple Geometrical/Statistical Model of Sea Ice Ridges. Naval Oceanographic Office, NSTL Station, MS, Technical Note 6130-5-75.

Hibler, W. D. (1972). Removal of Aircraft Altitude Variations from Laser Profiles of the Arctic Ice Pack. J. Geophys. Res., 77, 36, p. 7190-95.

Holyer, I. J. J., P. Wadhams, and R. T. Lowry (1977). An Interactive Graphics System for Reduction of Airborne Laser Profiles of Sea Ice. Scott Polar Research Institute, Cambridge, England, Tech. Rep. 77-1.

TABLE 1

COMPUTER LISTING OF DIGITAL PROFILE DATA NEAR A DATA SHIFT

READ NO. 2

NORMAL COMPLETION: 5 RECORDS

RECORD = 2

PROCESSING BEGINS ON RECORD 2

VALUES FOR STORAGE (121)

1386	1396	1446	1452	1446	1421	1426	1475	1446	1474	14 6	1472	144	1476	1444	1424	1504	1457	1441	1369
1372	1425	1441	1458	1443	1514	1544	1524	1513	151	14 2	1346	1542	1514	1569	1556	1544	1519	1394	1513
1466	1496	1476	1482	1462	15 4	[redacted]	1457	152	156	1576									
1588	1566	1552	1552	1458	1572			9	4	7	-55	-52	-63	-32	21	44	93	36	90
35	52	25	19	33	-2	22	49	58	91	74	72	1 8	1 2	76	69	75	72	136	135
96	81	172	169	138	147	143	131	121	154										

* after data pt. # 5127 add +1600

TABLE 2

HAND REMOVAL OF A "DROPOUT"

READ NO. 1

NORMAL COMPLETION: 5 RECORDS

RECORD = 1

PROCESSING BEGINS ON RECORD 1

VALUES FOR STORAGE (5351)

5313

	-299	-333	-297	-183	-633	-137	-27	-53	-5		4	3						
										4 4	6 6	6	664	7 4	652	654	662	6 6	7 4
595	733	749	701	742	681	739	694	721	754	7 4									
654	7 8	6 5	717	672	661	666	661	65	62	5 5	5 6	59	654	6 2	672	731	720	756	777
723	755	746	757	747	75	751	741	764	74	6 4	5 2	6 1	729	6 2	741	764	709	709	763
722	772	7 5	69	66	66	66	65	65	61										

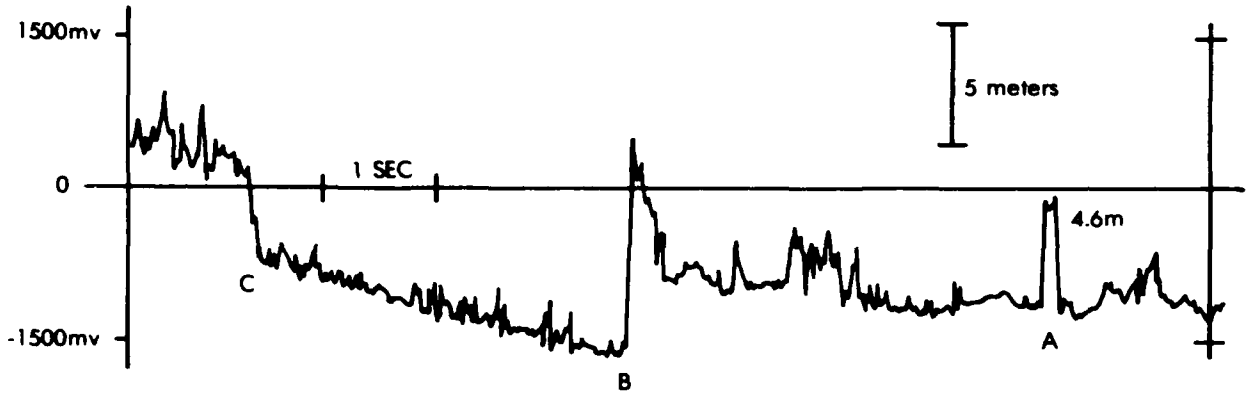

Figure 1. Example of raw sea ice profile data showing ridges, discontinuities, and aircraft motion

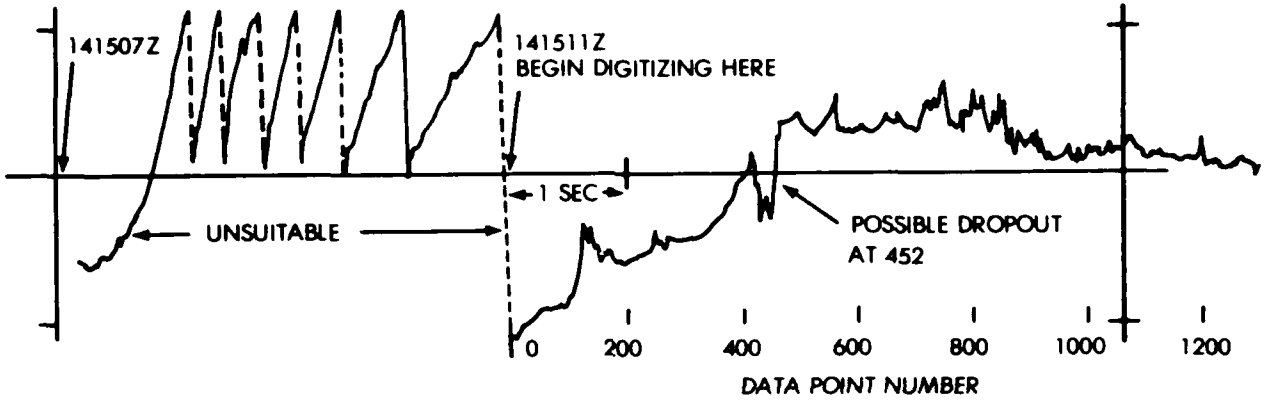

Figure 2. Hand-annotated review of typical sea ice profile data

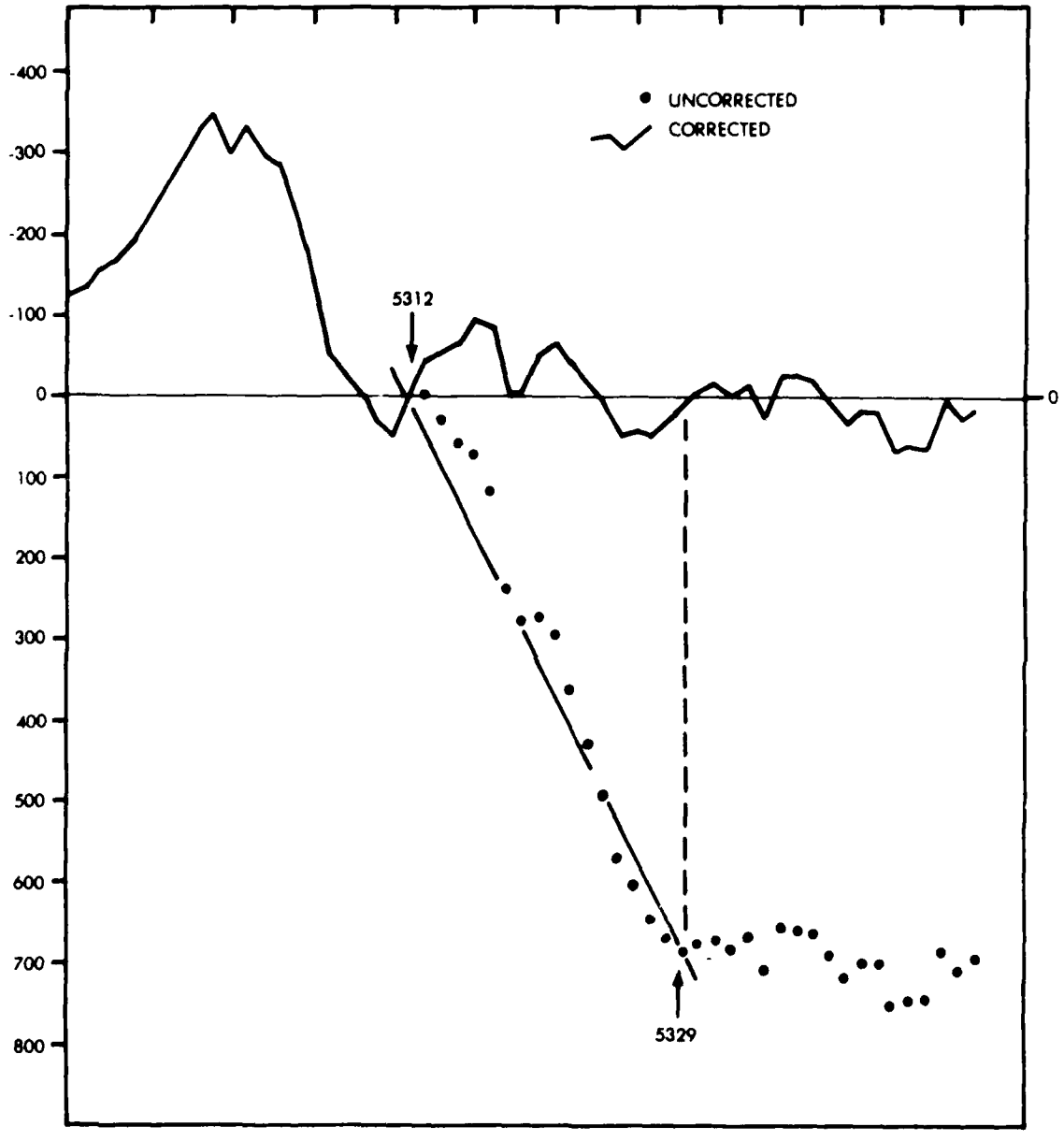

Figure 3. Plot of correction for a "dropout"

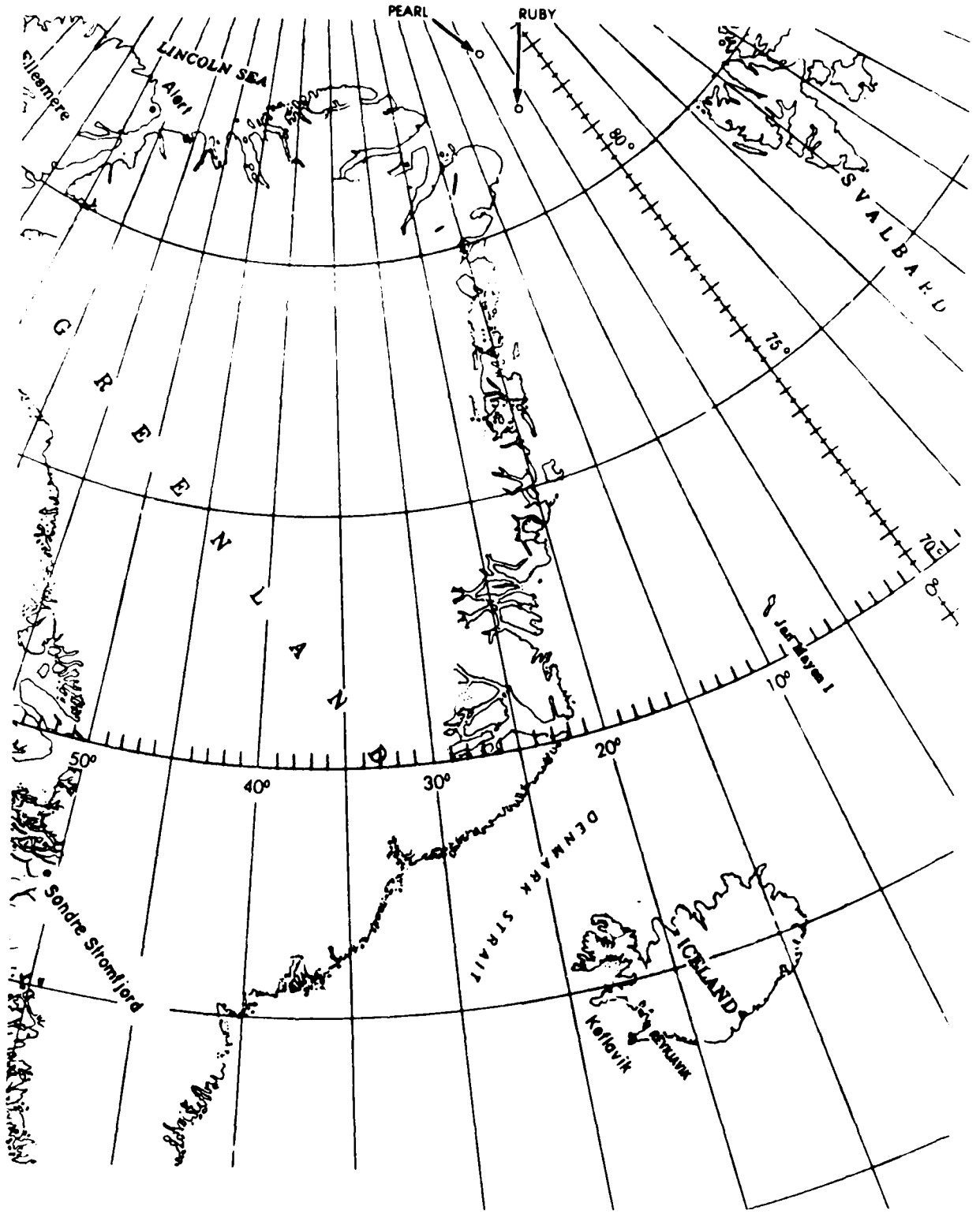

Figure 4. Map showing location of Sea Ice Camps Ruby and Pearl on 12 April 1977

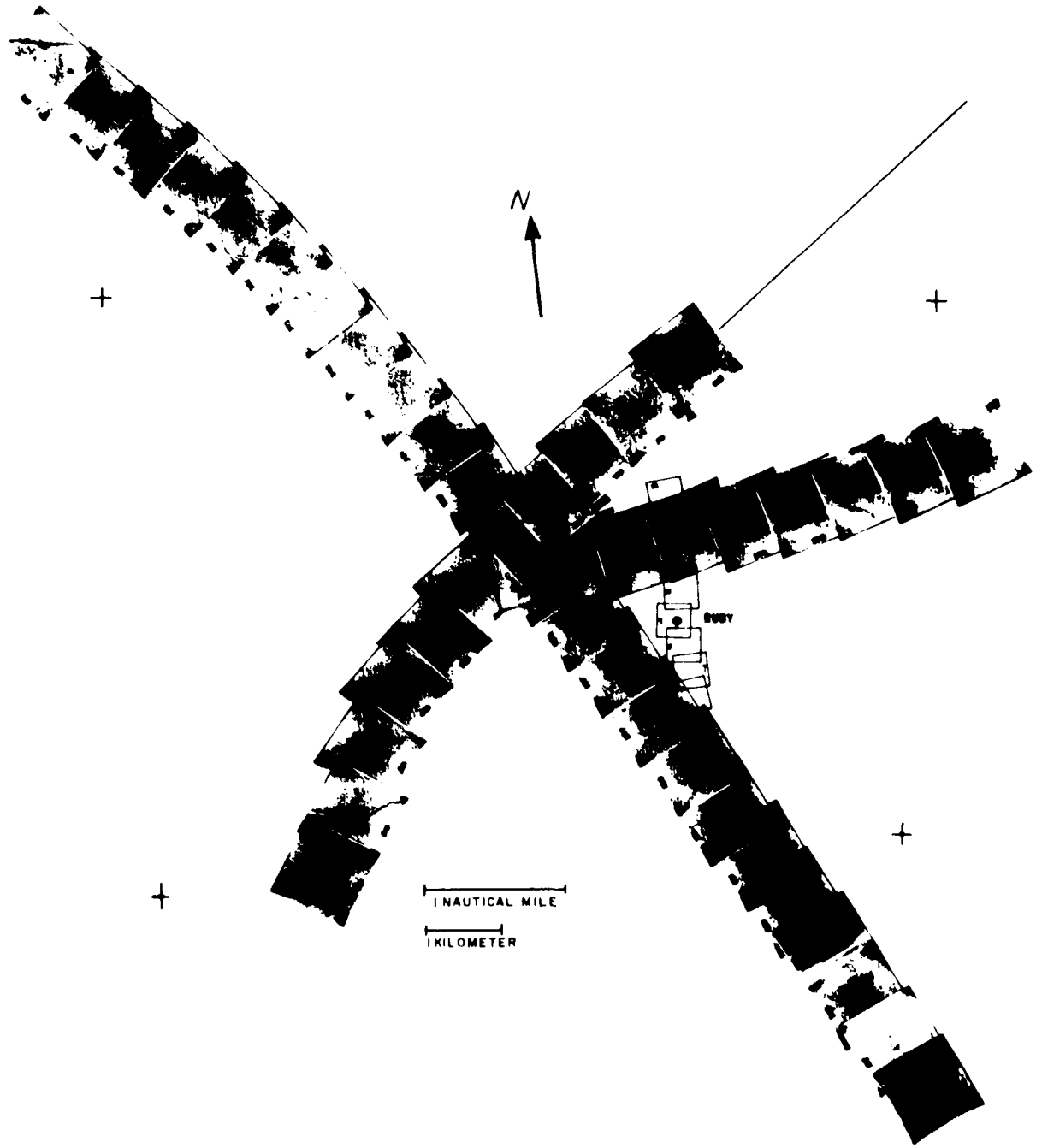

Figure 5. Uncontrolled Photomosaic of sea ice near Camp Ruby on 12 April 1977

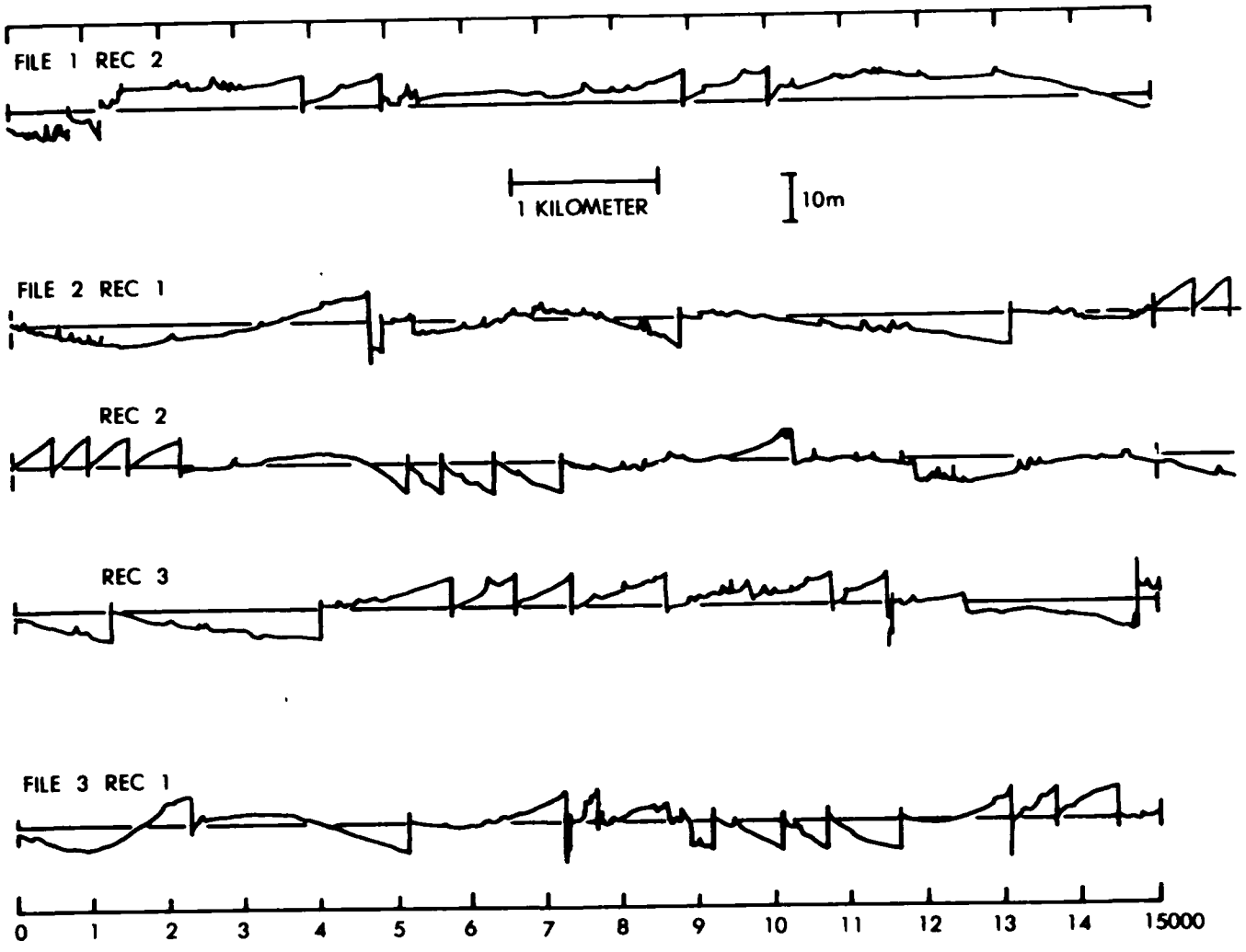

Figure 6. Uncorrected sea ice profile data near Camp Ruby, 12 April 1977

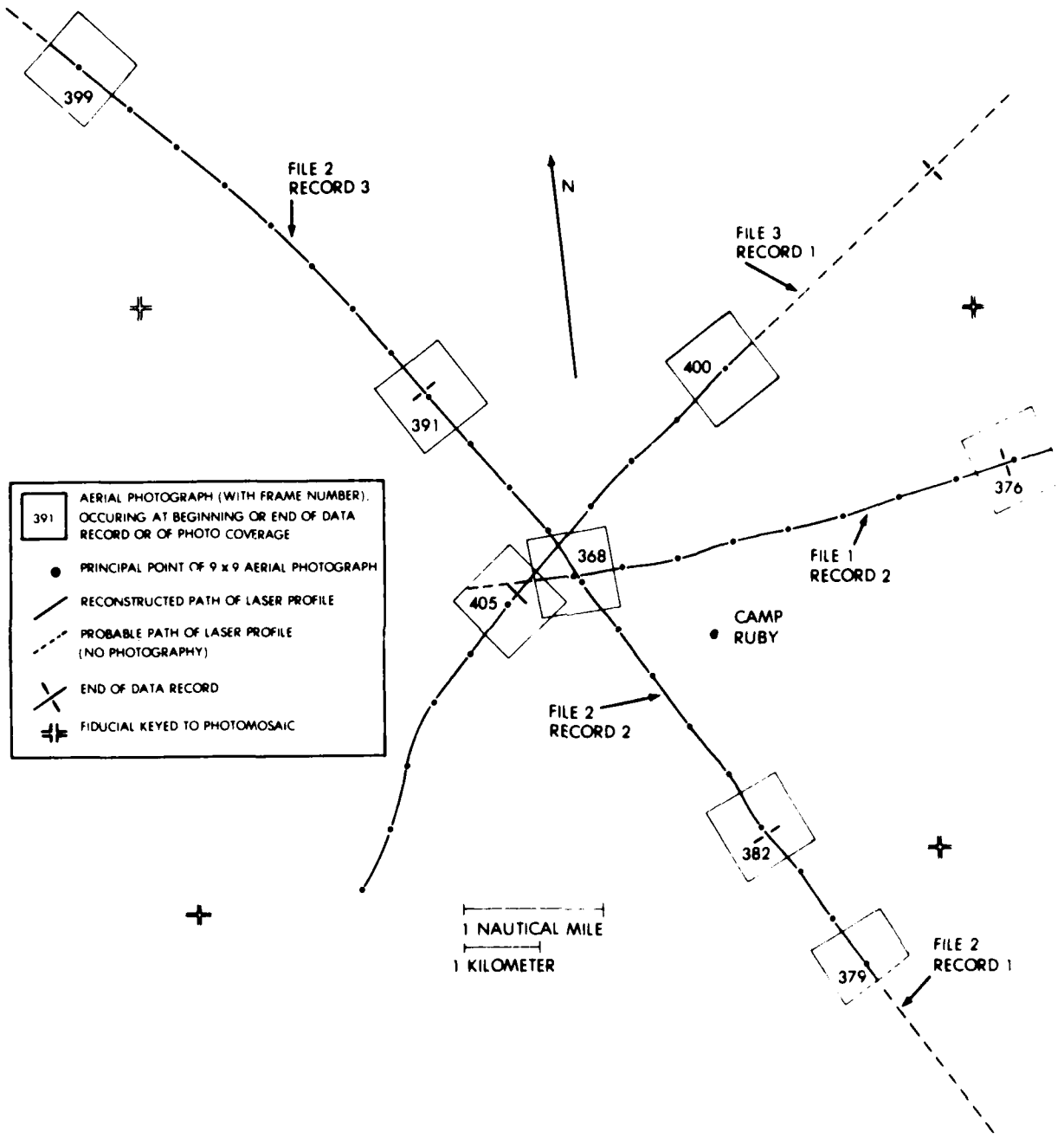

Figure 7. Location of sea ice profiles with respect to Camp Ruby, 12 April 1977

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     SAMPLE  75.  SECONDS
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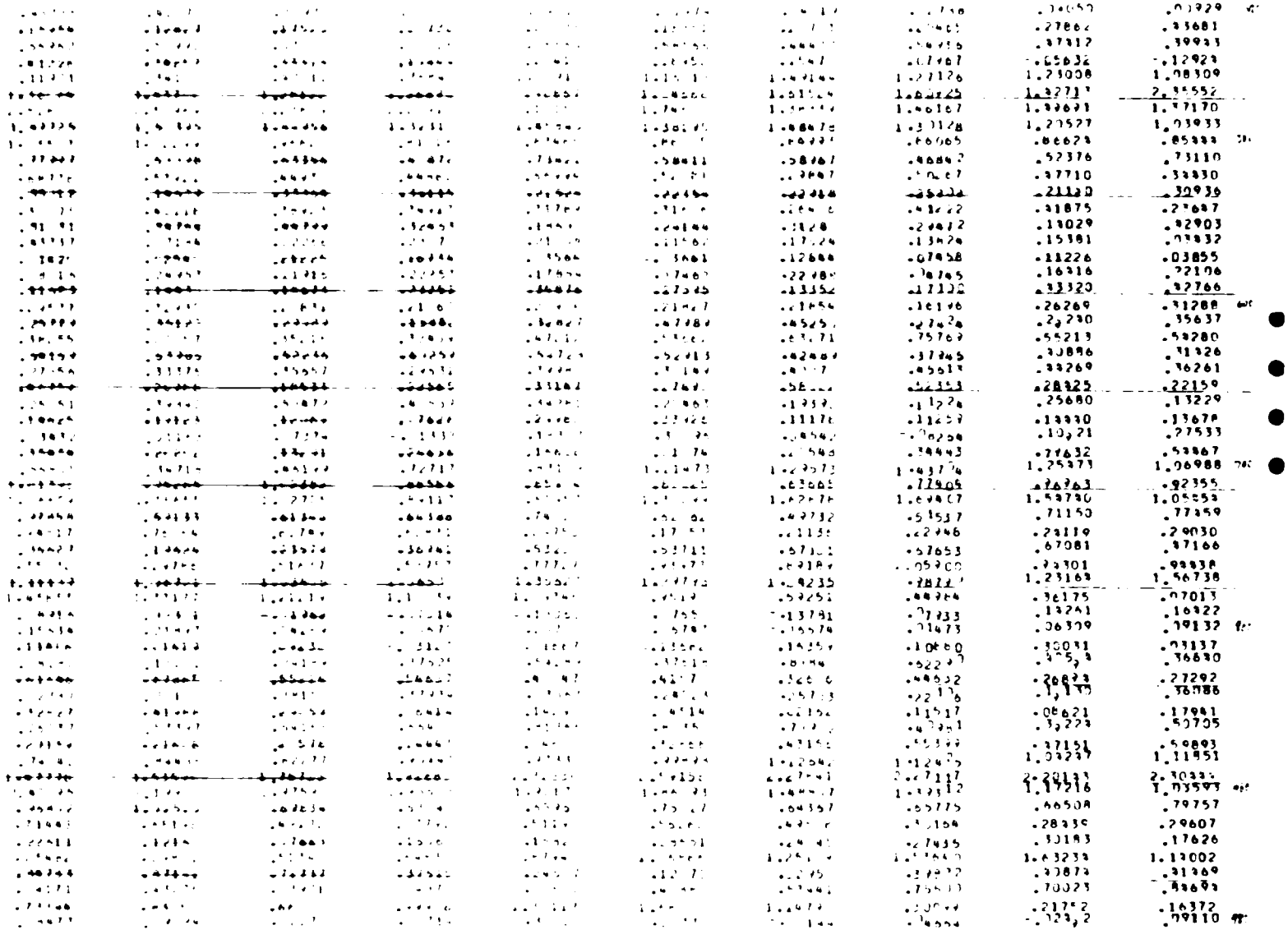

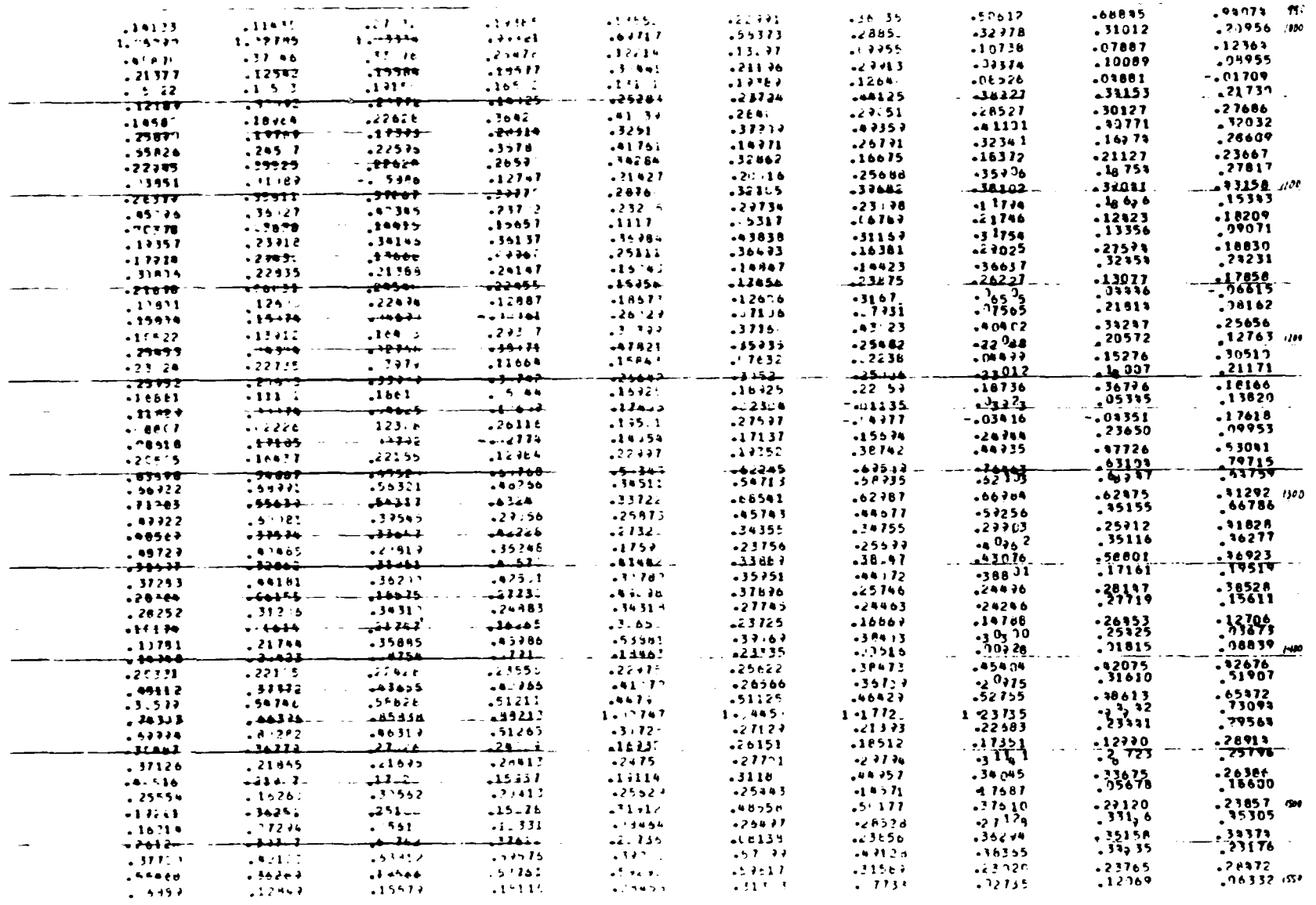

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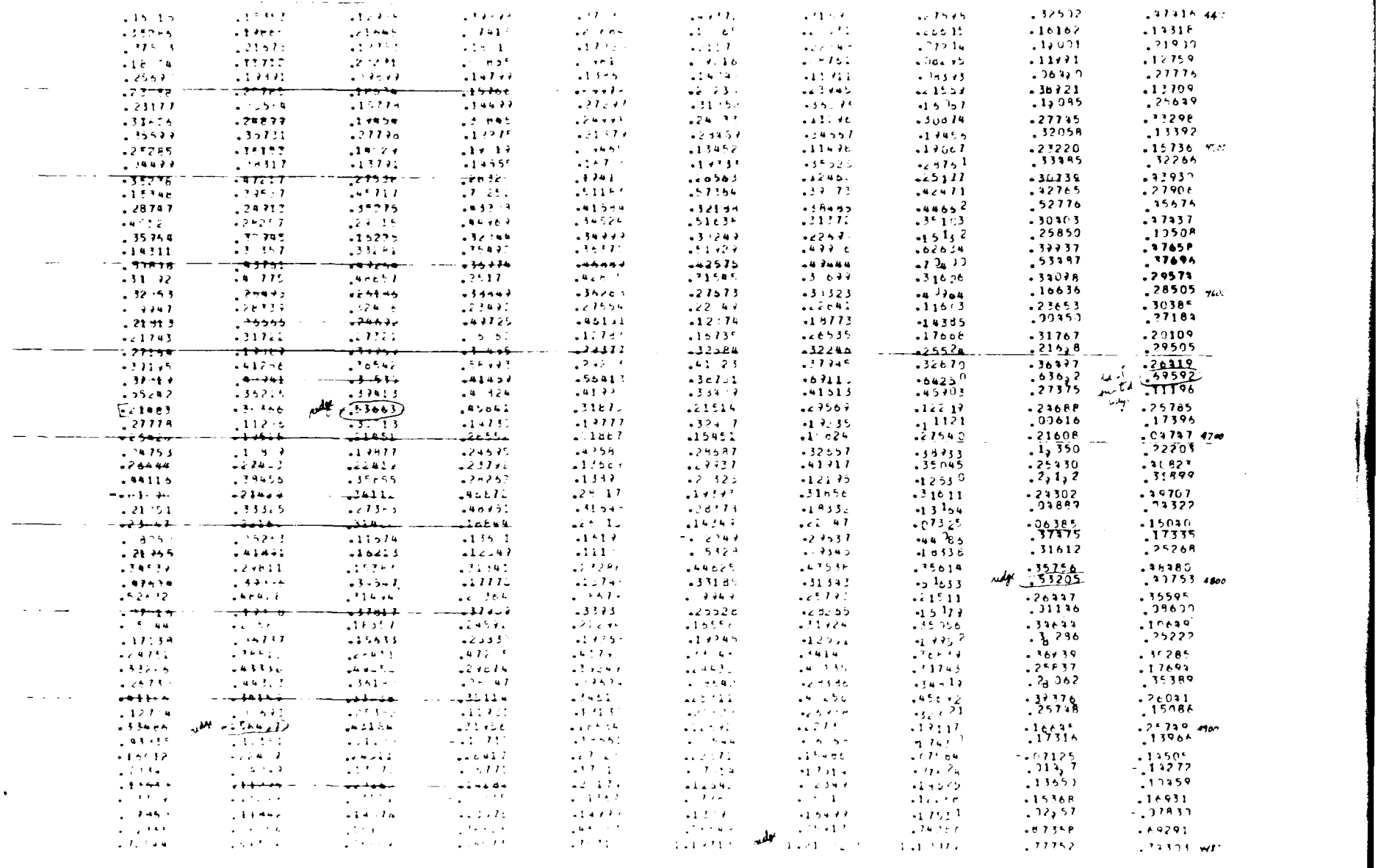

/ ...E TSMODE,1

ARGUMENT LIST FOR APPROPRIATE SUBROUTINE:

TAPE ID: RADIALS 6/27/77 RECORD 1
CALL NO. 1

4979 DATA POINTS
BEGIN AT 1
END AT 4980

HORSC 1.47 METERS/DATA POINT
SMPTIM 75.0 SECONDS
GROUNDSPEED 190.0 KNOTS

VERTICAL SCALE 12.192 METERS (ALREADY APPLIED)

2,1,1

Y(I) VALUES ARE

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ARGUMENT LIST FOR APPROPRIATE SUBROUTINE:

TAPE ID: RADIALS 6/27/77 RECORD 2
CALL NO. 2

8979 DATA POINTS
BEGIN AT 1
END AT 8980

HORSC 1.47 METERS/DATA POINT
SMPTIM 75.0 SECONDS
GROUNDSPEED 190.0 KNOTS

VERTICAL SCALE 12.192 METERS (ALREADY APPLIED)

2,2,1

Y(I) VALUES ARE

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2,2,4

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.42555	.48550	.22714	.19609	.28918	.22426	.28564	.18488	.07317	-.03784	
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.48416	.33876	.29980	.24653	.59560	.47631	.53617	.53791	.36337	.49365	
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.27242	.16945	.20890	.20689	.22745	.40200	.18276	.09987	.43773	.01212	4400

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.53899	.49301	.56448	.58909	.69645	.46672	.59456	.39769	.34870	.26920	
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.33350	.41844	.42396	.33549	.42292	.31852	.32326	.26130	.27120	.31926	
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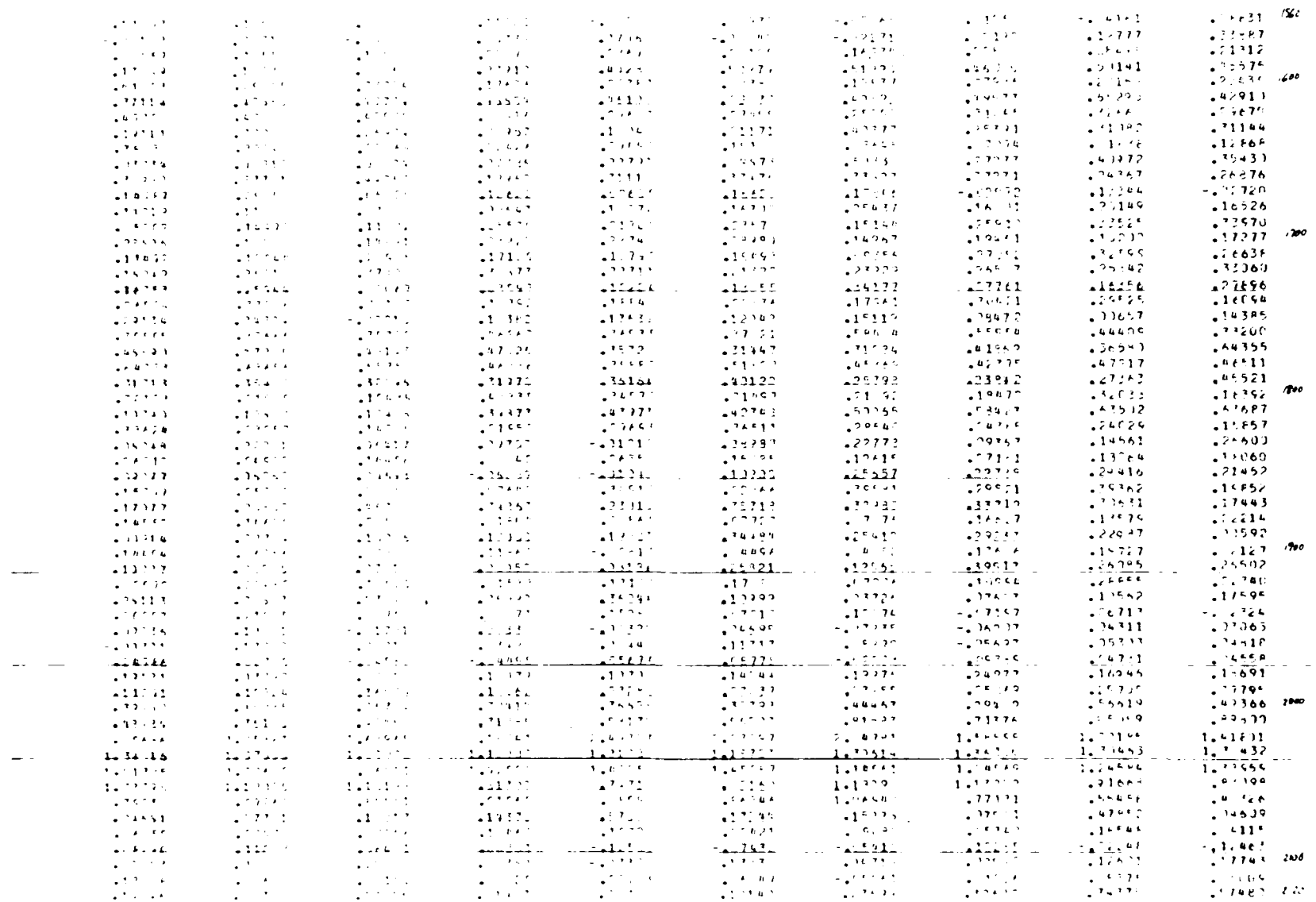

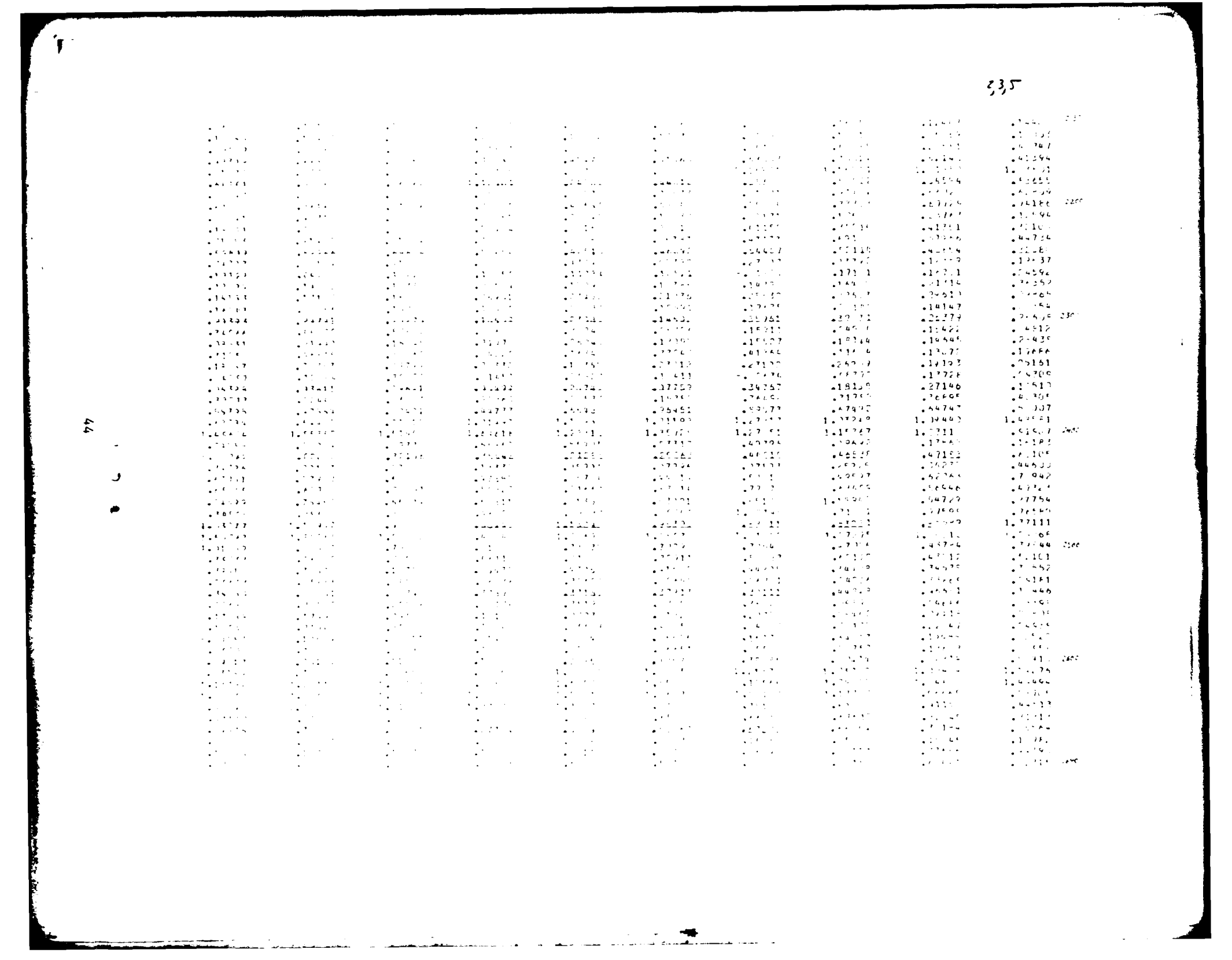

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ARGUMENT LIST FOR APPROPRIATE SUBROUTINE:

TAPE ID: RADIALS 1/23/78 RECORD 1
CALL NO. 1

4979 DATA POINTS
BEGIN AT 1
END AT 4979

MORSE 1.83 METERS/DATA POINT
SPOTIM 75.0 SECONDS
GROUNDSPEED 210.0 KNOTS

VERTICAL SCALE 12.192 METERS (ALREADY APPLIED)

311

Y(I) VALUES ARE

.54668	.55275	.57231	.41174	.51184	.47219	.3963	.54695	.50435	.58203
.48813	.4915	.76191	.61624	.66496	.66228	.57979	.58044	.61851	.62282
.42767	.39755	.39117	.28952	.1944	.16245	.32537	.38436	.37196	.53991
.52751	.67542	.60058	.53047	.42554	.51386	.56763	.46214	.42193	.31625
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.15931	.14285	.14325	-.03114	.11499	-.03159	.18011	.10306	.15238	.25693
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.36263	.21199	.23287	.20931	.33194	.24143	.2627	.31576	.11477	.08026
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.19136	.37561	.28477	.37192	.35887	.3512	.56321	.52951	.61822	.73222 400
.58387	.4374	.45798	.35229	.33697	.33591	.1696	.31785	.24097	.22891 410

.24168	.18825	.24772	.44284	.3[illegible]9	.27484	.15826	.34452	.25645	.30212
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.14156	.[illegible]24[illegible]4	.12749	.13791	.13741	.26481	.17334	.15990	.14686	.23390
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.325[illegible]	.2176[illegible]	.21534	.17761	.1437	.14742	.12115	.17766	.17020	.20290
.13717	.27778	.56894	.37179	.26[illegible]21	.27176	.16572	.05325	.11337	.26529
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.11717	.27638	.11621	.3[illegible]576	.1778[illegible]	.36414	.68[illegible]21	.41737	.21804	.23310
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51

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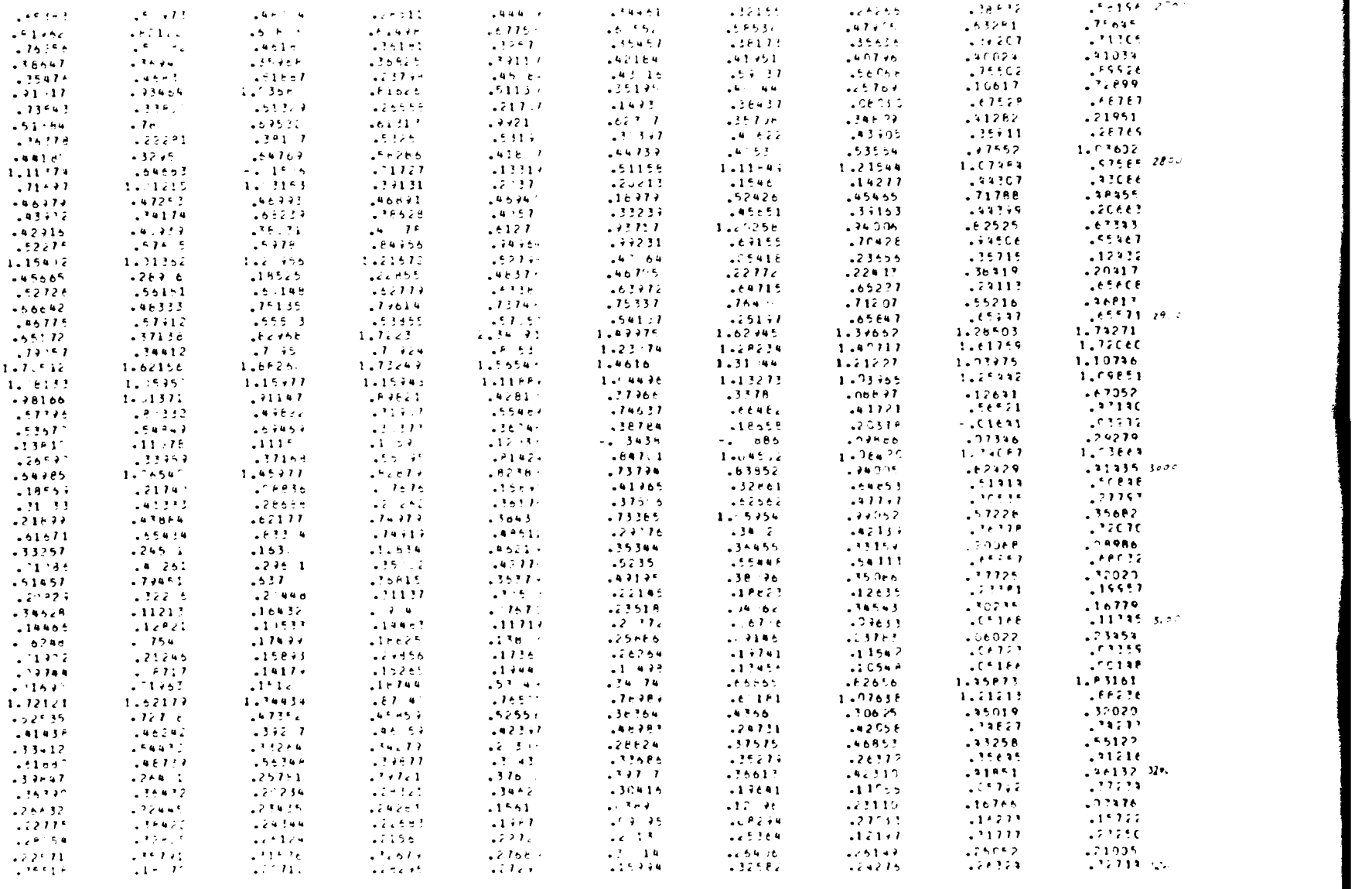

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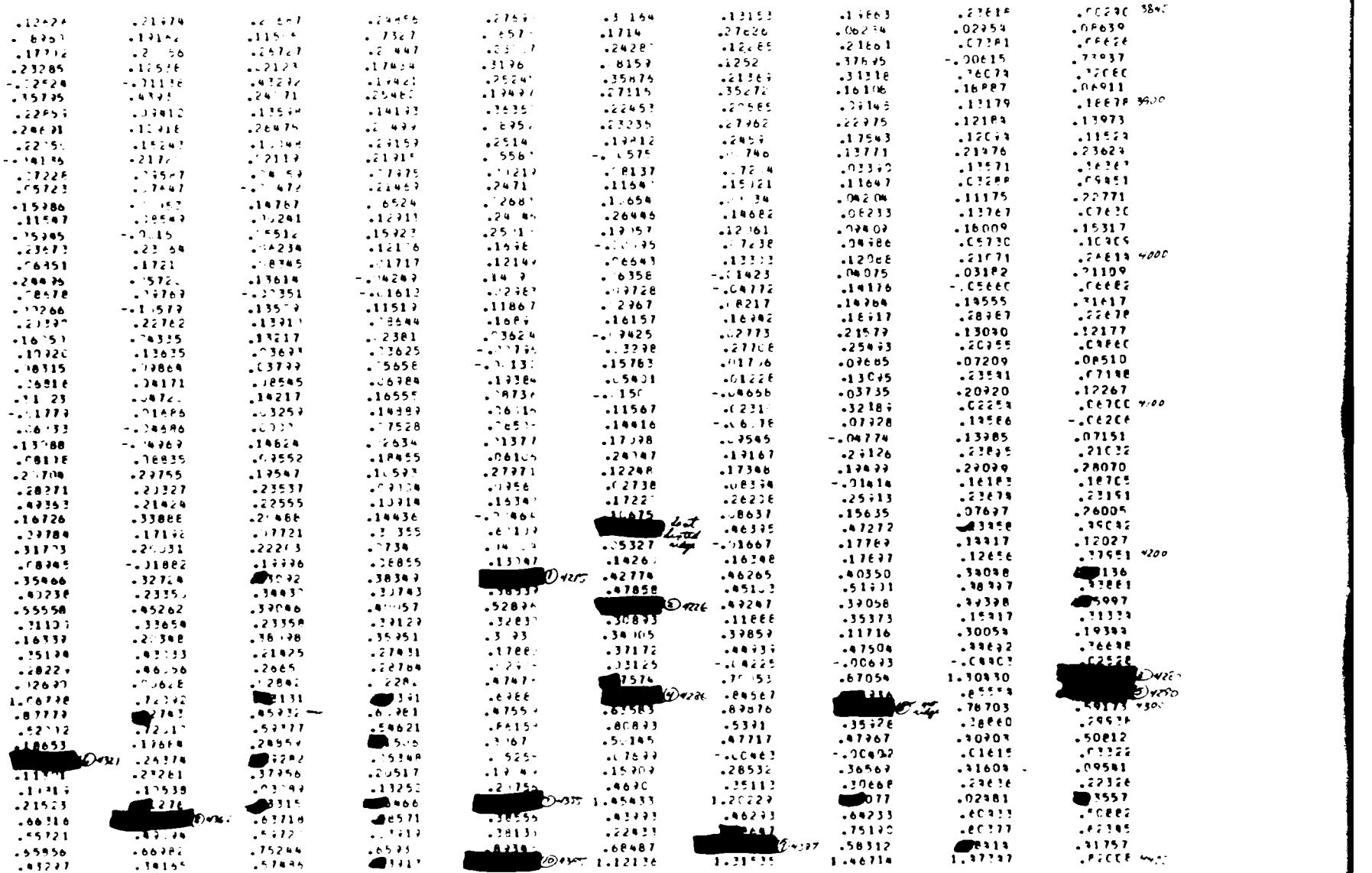
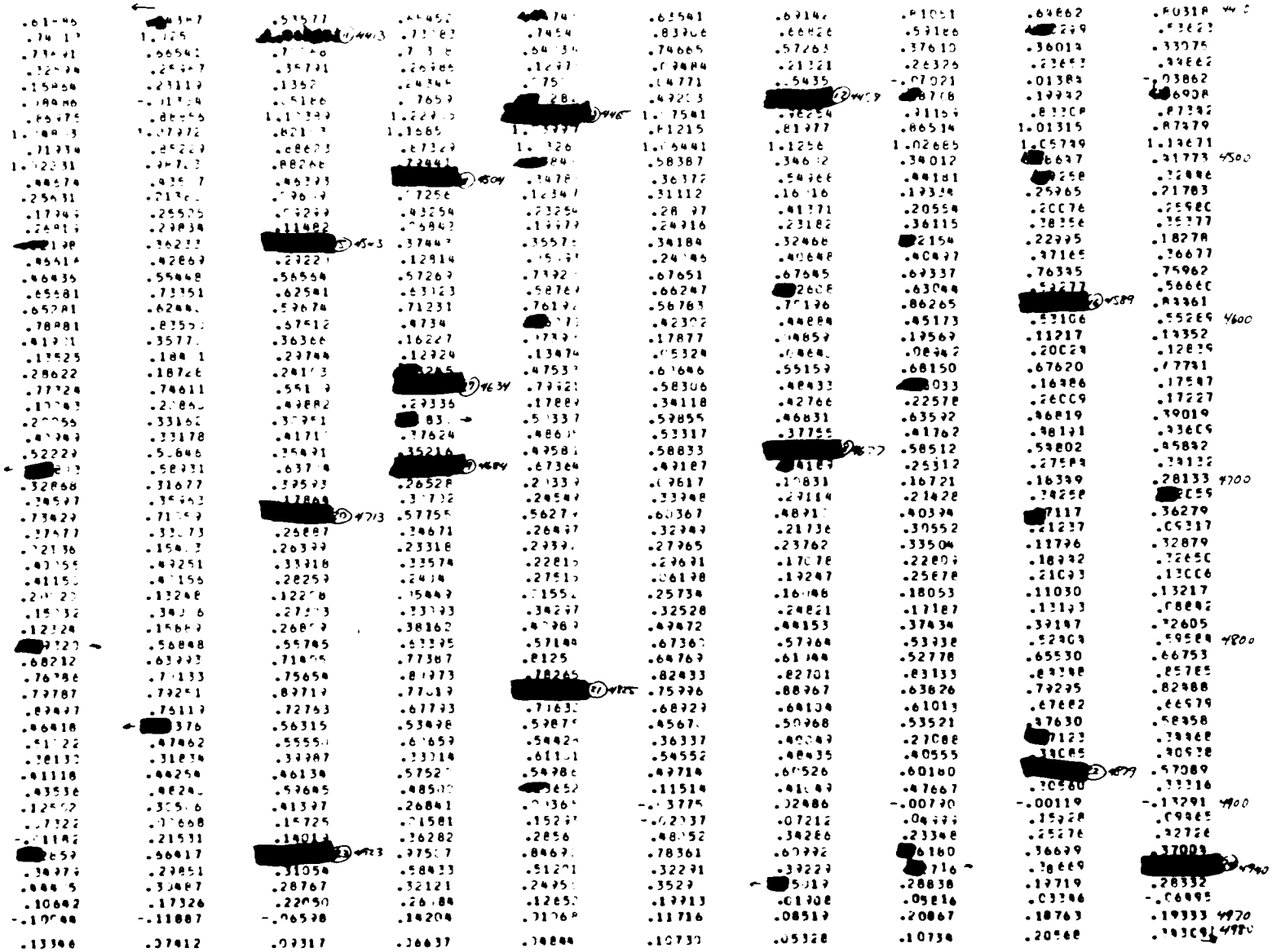




APPENDIX B

SUMMARY OF PROFILE ANALYSIS

FILE 1 RECORD 2

AIRCRAFT GROUNDSPEED 190.0 KNOTS
DATA POINT SPACING 1.5 METERS
POINTS 1 - 497 (7.33 MPS)

1	.7				.71						
2	.7				.69						
3	.64				.67						
4	1.19				.93						
5	1.07				.94						
6	.63				1.0						
7	.46				.5						
8	.58				.61						
9	1.07				.84						
10	.96				.93						
11	.74				.77						
12	.92				.86						
13	.71				.71						
14	.7				.82						
15	1.74				.89						
16	.96				.96						
17	1.11				.89						
18	.73				.82						
19	1.31				.93						
20	.5				.81						
21	.67				.89						
22	2.95				.96						
23	.61				.65						
24	.76				.73						
25	.65				.62						
26	.51				.68						
27	.8				.72						
28	1.44				.88						
29	1.69				.91						
30	.66				.74						
31	1.57				.85						
32	.81				.91						
33	.49				.93						
34	2.53				.88						
35	.56				.92						
36	1.63				.92						
37	1.59				.91						
38	1.4				.94						
39	.54				.83						
40	.4				1.06		4.31	12	.7	436	5.08
								121	.536	4673	
								122	.532	4799	
								123	.584	4892	

HIGHEST RIDGE 2.94 METERS AT I = 14

STATISTICS OF COUNTED RIDGES

HEIGHT RANGE (M)	# IN RANGE	#/KM
.5 < Z < .8	76	10.4
.8 < Z < 1.1	11	1.5
1.1 < Z < 1.4	13	1.8
1.4 < Z < 1.7	7	1.0
1.7 < Z < 2.0	3	.4
2.0 < Z < 2.3	2	.3
2.3 < Z < 2.6	5	.7
2.6 < Z < 2.9	1	.1
2.9 < Z < 3.2	0	.0
3.2 < Z < 3.5	1	.1
3.5 < Z < 3.8	1	.1
3.8 < Z < 4.1	1	.1
4.1 < Z < 4.4	0	.0
4.4 < Z < 4.7	0	.0
Z > 4.7	0	.0

PROFILE STATISTICS

MEAN	.37	METERS
ROOT MEAN SQUARE	.67	METERS
VARIANCE	.23	METERS**2
STANDARD DEVIATION	.48	METERS
SKEWNESS	2.63	
KURTOSIS	12.67	

FILE 2 RECORD 1

AIRCRAFT GROUNDSPEED 190.0 KNOTS
DATA POINT SPACING 1.5 METERS
POINTS 1- 4979 (7.33 KMS)

RIDGES COUNTED (111) Z = HEIGHT I = POSITION OF DATA POINT

#	Z(M)	I =	KM	#	Z(M)	I =	KM	#	Z(M)	I =	KM
1	.36	14	.02	41	1.41	1984	2.92	81	1.48	7553	5.27
2	1.47	78	.06	42	1.46	2068	3.04	82	.58	3637	5.35
3	1.65	57	.08	43	1.04	2135	3.14	83	.95	7658	5.39
4	.57	90	.13	44	2.39	2206	3.25	84	.60	7674	5.41
5	.77	124	.18	45	.73	2247	3.31	85	.51	3694	5.44
6	.61	145	.21	46	2.47	2317	3.41	86	.50	7697	5.44
7	2.41	208	.31	47	.98	2379	3.50	87	1.88	3737	5.50
8	1.57	261	.38	48	1.29	2390	3.52	88	1.30	7792	5.58
9	.67	272	.40	49	1.39	2439	3.59	89	.63	7807	5.61
10	1.36	289	.43	50	.57	2453	3.61	90	.84	3836	5.65
11	.89	298	.44	51	1.49	2503	3.68	91	.97	7847	5.66
12	.84	306	.45	52	.96	2529	3.72	92	1.68	3857	5.68
13	1.59	321	.47	53	.85	2550	3.75	93	.86	3906	5.75
14	1.68	337	.50	54	1.71	2585	3.81	94	1.28	3927	5.78
15	1.65	366	.54	55	.66	2661	3.92	95	.59	4021	5.92
16	2.16	395	.58	56	.70	2694	3.95	96	.58	4042	5.95
17	.56	410	.60	57	.62	2718	4.00	97	.66	4068	5.99
18	.60	435	.64	58	.63	2720	4.00	98	.63	4078	6.00
19	.62	453	.67	59	.71	2725	4.01	99	.60	4089	6.02
20	.57	597	.88	60	.75	2731	4.02	100	.59	4113	6.06
21	1.43	721	1.06	61	2.23	2761	4.07	101	.56	4441	6.54
22	.60	883	1.30	62	2.68	2784	4.10	102	1.09	4542	6.69
23	.78	961	1.41	63	.66	2807	4.13	103	1.53	4571	6.73
24	1.15	1093	1.61	64	1.39	2853	4.20	104	.51	4606	6.78
25	.61	1173	1.73	65	.76	2869	4.22	105	1.23	4621	6.80
26	.61	1203	1.77	66	.73	2876	4.23	106	.61	4670	6.88
27	.62	1250	1.84	67	.66	2891	4.26	107	.73	4780	7.04
28	.50	1285	1.89	68	1.15	3006	4.43	108	.60	4866	7.16
29	.50	1295	1.91	69	1.18	3024	4.45	109	1.31	4896	7.21
30	.56	1307	1.92	70	.68	3046	4.49	110	1.23	4926	7.25
31	.54	1336	1.97	71	1.08	3061	4.51	111	1.57	4965	7.31
32	1.32	1358	2.00	72	.67	3093	4.55	112	.00	0	.00
33	.59	1436	2.11	73	.77	3114	4.58	113	.00	0	.00
34	1.64	1601	2.36	74	.99	3160	4.65	114	.00	0	.00
35	.57	1683	2.48	75	1.21	3178	4.68	115	.00	0	.00
36	1.77	1742	2.56	76	.66	3197	4.71	116	.00	0	.00
37	1.67	1758	2.59	77	.58	3253	4.79	117	.00	0	.00
38	.77	1778	2.62	78	.77	3275	4.82	118	.00	0	.00
39	1.08	1810	2.66	79	.56	3311	4.87	119	.00	0	.00
40	.93	1849	2.72	80	.52	3524	5.19	120	.00	0	.00

HIGHEST RIDGE 2.91 METERS AT I = 208

STATISTICS OF COUNTED RIDGES

HEIGHT RANGE (M)	# IN RANGE	#/KM
.5 < Z < .8	50	6.8
.8 < Z < 1.1	24	3.3
1.1 < Z < 1.4	14	1.9
1.4 < Z < 1.7	10	1.4
1.7 < Z < 2.0	7	1.0
2.0 < Z < 2.3	2	.3
2.3 < Z < 2.6	2	.3
2.6 < Z < 2.9	1	.1
2.9 < Z < 3.2	1	.1
3.2 < Z < 3.5	0	.0
3.5 < Z < 3.8	0	.0
3.8 < Z < 4.1	0	.0
4.1 < Z < 4.4	0	.0
4.4 < Z < 4.7	0	.0
Z > 4.7	0	.0

PROFILE STATISTICS

MEAN	.41	METERS
ROOT MEAN SQUARE	.56	METERS
VARIANCE	.14	METERS**2
STANDARD DEVIATION	.38	METERS
SKEWNESS	2.00	
KURTOSIS	8.39	

FILE 2 RECORD 2

AIRCRAFT GROUNDSPEED 190.0 KNOTS
DATA POINT SPACING 1.5 METERS
POINTS 1- 4979 (7.33 KMS)

RIDGES COUNTED (116) Z = HEIGHT I = POSITION OF DATA POINT

#	Z(M)	I =	KM	#	Z(M)	I =	KM	#	Z(M)	I =	KM
1	2.62	299	.44	41	.68	2087	3.07	81	.51	3602	5.30
2	.75	310	.46	42	1.19	2101	3.09	82	1.21	3655	5.38
3	2.26	331	.49	43	1.20	2141	3.15	83	1.28	3663	5.39
4	.75	436	.64	44	.62	2156	3.17	84	.70	3689	5.43
5	.62	593	.86	45	1.45	2191	3.23	85	.66	3703	5.45
6	.59	598	.88	46	.54	2207	3.25	86	.61	3710	5.46
7	.66	627	.92	47	1.22	2355	3.47	87	1.77	3728	5.49
8	.59	681	1.00	48	.52	2395	3.51	88	1.04	3746	5.52
9	1.47	711	1.05	49	.55	2456	3.62	89	.85	3801	5.60
10	.65	753	1.11	50	.51	2468	3.63	90	.67	3813	5.61
11	.61	772	1.14	51	1.54	2505	3.69	91	2.03	3851	5.67
12	.56	788	1.16	52	1.82	2636	3.88	92	.58	3885	5.72
13	.61	822	1.21	53	.79	2655	3.91	93	.70	3907	5.75
14	2.34	943	1.39	54	.64	2666	3.93	94	.51	3918	5.77
15	.62	1090	1.60	55	1.10	2679	3.94	95	.59	3925	5.78
16	.59	1165	1.72	56	1.17	2699	3.97	96	.57	3965	5.84
17	.63	1200	1.77	57	1.87	2774	4.08	97	1.61	3982	5.86
18	.60	1260	1.86	58	.72	2799	4.12	98	2.26	4014	5.91
19	.61	1277	1.88	59	1.73	2846	4.19	99	1.13	4034	5.94
20	.72	1296	1.91	60	.67	2877	4.24	100	.98	4054	5.97
21	.80	1334	1.96	61	.53	2885	4.25	101	.70	4059	5.98
22	.59	1412	2.08	62	.53	2890	4.26	102	1.99	4083	6.01
23	.57	1426	2.10	63	1.03	2908	4.28	103	.89	4123	6.07
24	.70	1460	2.15	64	.81	3053	4.50	104	.69	4147	6.11
25	.69	1479	2.18	65	.83	3152	4.64	105	.60	4215	6.21
26	.82	1527	2.25	66	.52	3166	4.66	106	1.97	4365	6.43
27	.90	1591	2.29	67	.51	3176	4.68	107	1.55	4420	6.51
28	.57	1605	2.47	68	1.28	3317	4.88	108	1.49	4462	6.57
29	.74	1702	2.51	69	1.56	3341	4.92	109	.52	4508	6.64
30	.79	1721	2.53	70	1.08	3354	4.94	110	.54	4586	6.75
31	.97	1731	2.55	71	.93	3361	4.95	111	.80	4621	6.80
32	.54	1763	2.60	72	2.61	3383	4.98	112	1.05	4646	6.84
33	.89	1816	2.67	73	.54	3403	5.01	113	.67	4711	6.94
34	1.17	1858	2.74	74	.74	3422	5.04	114	.63	4748	6.99
35	1.45	1927	2.84	75	.97	3434	5.06	115	1.76	4841	7.13
36	.62	1953	2.88	76	2.53	3470	5.11	116	.53	4937	7.27
37	1.42	2005	2.95	77	.69	3511	5.17	117	.30	?	.30
38	1.21	2027	2.98	78	.93	3523	5.19	118	.00	?	.00
39	1.05	2048	3.02	79	.65	3573	5.26	119	.00	?	.00
40	.64	2065	3.04	80	.52	3583	5.28	120	.00	?	.00

HIGHEST RIDGE 2.62 METERS AT I = 299

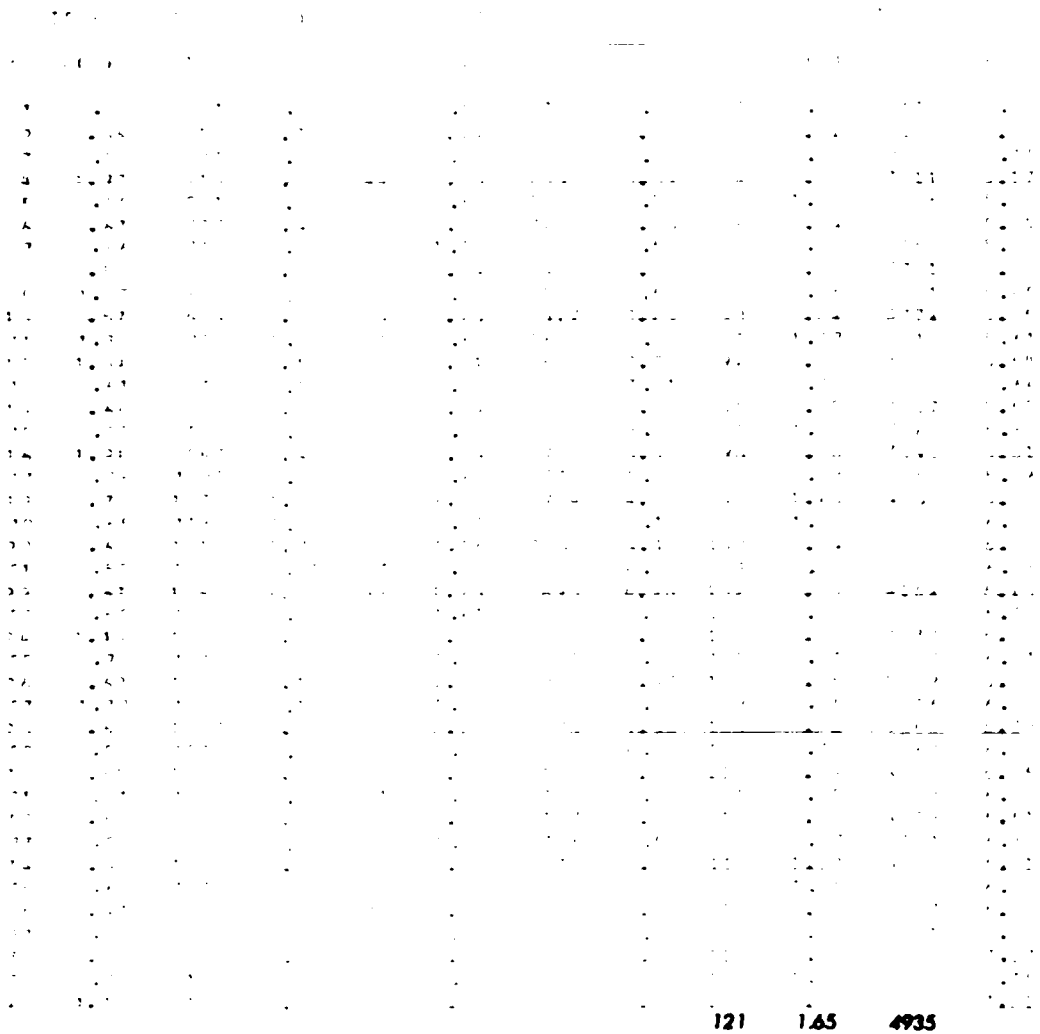
STATISTICS OF COUNTED RIDGES

HEIGHT RANGE (M)	# IN RANGE	#/KM
.5 < Z < .8	61	8.3
.8 < Z < 1.1	22	3.0
1.1 < Z < 1.4	11	1.5
1.4 < Z < 1.7	7	1.0
1.7 < Z < 2.0	8	1.1
2.0 < Z < 2.3	3	.4
2.3 < Z < 2.6	2	.3
2.6 < Z < 2.9	2	.3
2.9 < Z < 3.2	0	.0
3.2 < Z < 3.5	0	.0
3.5 < Z < 3.8	0	.0
3.8 < Z < 4.1	0	.0
4.1 < Z < 4.4	0	.0
4.4 < Z < 4.7	0	.0
Z > 4.7	0	.0

PROFILE STATISTICS

MEAN	.91	METERS
ROOT MEAN SQUARE	.95	METERS
VARIANCE	.14	METERS**2
STANDARD DEVIATION	.37	METERS
SKEWNESS	2.05	
KURTOSIS	8.25	

FILE 2 RECORD 3



121	1.65	4935
122	3.05	4942

FILE 3 RECORD 1

AIRCRAFT GROUNDSPEED 210.0 KNOTS
DATA POINT SPACING 1.6 METERS
POINTS I= 4979 (8.10 KMS)

RIDGES COUNTED (1440) Z = HEIGHT I = POSITION OF DATA POINT

#	Z(M)	I =	KM	#	Z(M)	I =	KM	#	Z(M)	I =	KM
1	.74	13	.0	41	.66	1455	2.37	81	.74	2751	4.48
2	.68	92	.15	42	.79	1497	2.38	82	.93	2765	4.51
3	1.13	95	.16	43	.95	1542	2.51	83	1.11	2791	4.54
4	.75	135	.2	44	.73	1553	2.53	84	1.02	2798	4.55
5	.55	166	.27	45	.7	1584	2.59	85	.72	2819	4.59
6	.56	259	.42	46	1.09	1621	2.64	86	1.03	2837	4.62
7	.74	4[illegible]	.45	47	.84	1626	2.65	87	1.12	2854	4.64
8	.57	513	.83	48	.53	1631	2.65	88	.65	2378	4.68
9	.53	527	.85	49	.73	1642	2.67	89	.50	2884	4.69
10	.7	541	.88	50	.67	1655	2.69	9	2.34	2905	4.73
11	.6	599	97	51	.52	1690	2.75	91	1.48	2923	4.76
12	.59	62	1.01	52	.64	1695	2.76	92	.[illegible]	2952	4.81
13	.69	577	1.4	53	1.11	1881	3.06	93	.75	2956	4.81
14	1.21	655	1.7	54	.69	1894	3.08	94	1.14	2989	4.86
15	1.02	664	1.09	55	.65	1972	3.21	95	1.46	2993	4.87
16	1.01	7[illegible]	1.1[illegible]	56	.62	2007	3.3	96	.45	3[illegible]8	4.89
17	.[illegible]	73[illegible]	1.1[illegible]	57	1.1	2056	3.35	97	.53	3117	4.91
18	.94	756	1.23	58	.63	21[illegible]9	3.43	98	1.6	3127	4.93
19	1.41	8[illegible]	1.31	59	1.11	2114	3.44	99	.23	3133	4.94
20	.89	79[illegible]	1.[illegible]	60	1.1	2122	3.45	100	.79	3152	4.98
21	1.[illegible]	8[illegible]3	1.36	61	.61	2135	3.47	101	1.03	314[illegible]	5.11
22	.58	8[illegible]6	1.39	62	.74	217[illegible]	3.53	102	1.01	3149	5.12
23	.67	9[illegible]	1.47	63	.54	2177	3.54	103	.94	3172	5.16
24	1.07	93[illegible]	1.51	64	.49	2179	3.57	104	.92	3181	5.18
25	.5	978	1.59	65	.62	2351	3.62	105	.55	3301	5.37
26	.[illegible]	987	1.61	66	1.49	2412	3.92	106	.91	3319	5.4[illegible]
27	.61	1[illegible]	1.66	67	.47	2451	3.99	107	1.08	3344	5.45
28	.63	1[illegible]	1.67	68	.56	2461	4.[illegible]	108	.97	3391	5.52
29	.76	1[illegible]	1.71	69	.62	2479	4.[illegible]3	109	1.08	3402	5.54
30	.97	1104	1.8	70	1.[illegible]	2487	4.05	110	1.[illegible]	3429	5.58
31	.51	1104	1.82	71	2.62	2549	4.14	111	.98	3491	5.68
32	.94	1[illegible]	1.85	72	.73	2566	4.21	112	.92	3498	5.69
33	.83	1[illegible]	1.87	73	1.3	2599	4.23	113	.92	3514	5.72
34	.91	1218	1.98	74	1.[illegible]	261	4.25	114	.91	3531	5.71
35	.69	1317	2.14	75	.64	2614	4.25	115	.97	3536	5.72
36	.79	13[illegible]	2.15	76	.73	2643	4.31	116	.96	3543	5.73
37	.62	13[illegible]	2.21	77	.68	2651	4.36	117	.92	3549	5.74
38	.67	1375	2.24	78	.75	2695	4.38	118	.7	3561	5.76
39	.57	148[illegible]	2.34	79	.82	27[illegible]	4.4[illegible]	119	.74	4[illegible]	6.[illegible]
40	.[illegible]	1444	2.[illegible]	8[illegible]	1.4	2743	4.44	12[illegible]	.74	4176	6.8

STATISTICS OF COUNTED RIDGES

HEIGHT RANGE (M)	# IN RANGE	#/KM
.5 < Z < .8	82	10.1
.8 < Z < 1.1	24	3.2
1.1 < Z < 1.4	15	1.9
1.4 < Z < 1.7	6	.7
1.7 < Z < 2.0	[illegible]	.6
2.0 < Z < 2.3	0	.0
2.3 < Z < 2.6	1	.1
2.6 < Z < 2.9	1	.1
2.9 < Z < 3.2	0	.0
3.2 < Z < 3.5	0	.0
3.5 < Z < 3.8	0	.0
3.8 < Z < 4.1	0	.0
4.1 < Z < 4.4	0	.0
4.4 < Z < 4.7	0	.0
Z > 4.7	0	.0

PROFILE STATISTICS

MEAN	.75	METERS
ROOT MEAN SQUARE	.96	METERS
VARIANCE	.09	METERS**2
STANDARD DEVIATION	.70	METERS
SKEWNESS	2.03	
KURTOSIS	10.09	

HIGHEST RIDGE [illegible].82 METERS AT I = 2059

121	0 54	4215	6 858	
122	0 65	4226	6 876	
123	1 38	4280	6 964	9 METERS
124	0 92	4286	6 973	7 METERS
125	1 32	4290	6 980	
126	0 51	4321	7 030	
127	1 84	4355	7 086	
128	1 06	4362	7 097	
129	1 05	4387	7 138	
130	1 55	4395	7 151	
131	1 06	4413	7 180	
132	0 63	4457	7 252	
133	1 24	4465	7 265	
134	0 60	4504	7 328	
135	0 51	4543	7 391	
136	0 90	4589	7 466	
137	0 81	4634	7 540	
138	0 65	4677	7 609	
139	0 69	4684	7 621	
140	0 74	4713	7 668	
141	0 97	4825	7 850	
142	0 61	4879	7 938	
143	1 07	4923	8 010	
144	0 53	4940	8 037	

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19 KEY WORDS (Continue on reverse side if necessary and identify by block number)

Airborne laser profiler
Sea ice surface profile
Sea ice ridge distributions
Sea ice profile statistics

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

This technical note reports the results of reduction and preliminary analysis of airborne-laser sea-ice surface profiles obtained in April 1977, from Fram Strait between northern Greenland and Spitzbergen. Data reduction consists of the removal of discontinuities in the profiles, and numerical computer filtering to remove aircraft motion. Analysis consists of computer calculations of descriptive statistics. The data set chosen is in proximity to an ice camp (Ruby) operated by personnel from the Polar Research Laboratory, Santa Barbar

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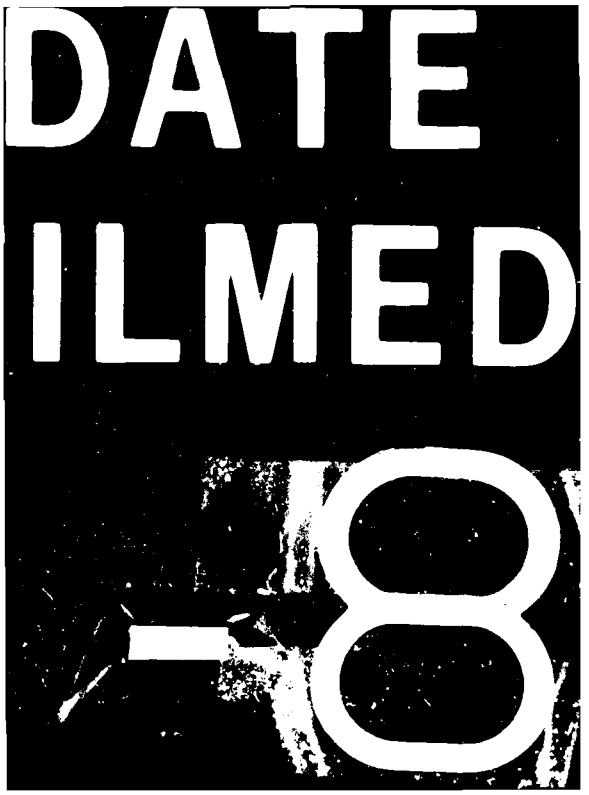
Santa Barbara, California. Aerial photography taken sumultaneously with the laser profiles serves to precisely place the profile data with respect to Camp Ruby on 12 April 1977.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